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Typical Indoor Air Concentrations

TECHNICAL UPDATE
POLICY #08-XXX

Review Draft for Discussion Purposes Only

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Updates:

"Indoor Air Background," MCP Numerical Standard Documentation, MassDEP, 1992, et seq, as a reference of indoor air chemical concentrations for use in evaluating a potential vapor intrusion pathway.

This document updates MassDEP's list of values representing chemical concentrations that may typically be present in indoor air from sources such as building materials, household products, and ambient air. These "Typical Indoor Air Concentrations," developed using recent studies of indoor air chemical concentrations measured in residences, may be used as one line of evidence in evaluating potential vapor intrusion pathways from a disposal site.

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Introduction

In 1992, MassDEP made available a list of "Indoor Air Background" values[1] for a small number of chemicals as part of its documentation on the development of MCP Method 1 GW-2 standards. Consistent with MassDEP guidance,[2] this list was also used by the regulated community as a reference for indoor air chemical concentrations that may be present in a building unaffected by a vapor intrusion pathway. In 2006, MassDEP directed the regulated community[3] to use more current published indoor air studies in lieu of the 1992 list when evaluating indoor air concentrations. MassDEP also convened a workgroup in January 2007, consisting of MassDEP staff, representatives from the Massachusetts Department of Public Health, environmental and scientific professionals, and other interested stakeholders (Workgroup), to evaluate the quality and appropriateness of more recent indoor air data sets for use in developing an updated list of indoor air chemical concentration values.

This document presents MassDEP's updated list of "Typical Indoor Air Concentrations" based on recent studies identified and reviewed by MassDEP with the assistance of the Workgroup, and describes the process used to select appropriate studies, and combine the data sets to develop these values. These values are indicative of the types and concentrations of chemicals that are typically present in indoor air from sources such as building materials, household products, and ambient air, absent any contribution from a vapor intrusion pathway. MassDEP's Typical Indoor Air Concentrations may be used as one of potentially several lines of evidence in evaluating whether measured concentrations of oil or hazardous materials (OHM) in indoor air are the result of a vapor intrusion pathway associated with a disposal site.

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A Note on Terminology

Please note that MassDEP is using the term "Typical Indoor Air Concentrations" instead of "Indoor Air Background" to refer to the updated list of indoor air values. MassDEP is intentionally avoiding the term "background" as "background" has specific MCP regulatory associations that may not always be intended or apply when discussing the use of indoor air values from studies as a line of evidence in a vapor intrusion pathway investigation.

In the context of the MCP, background is the level of OHM present at a location absent a release to the environment. For indoor air, background is what is present in any given structure, absent a vapor migration pathway related to a release. Background levels do not require mitigation under the MCP. Background in any particular medium is typically determined by measuring the levels of OHM in nearby, similar areas that have not been affected by a release of OHM. For soil and groundwater, background concentrations can be determined by collecting samples from nearby, similar, unaffected properties. However, background indoor air concentrations are not as easily determined. Due to variations in building materials, use and storage of consumer products, ventilation rates, and other factors specific to each structure, indoor air chemical concentrations observed in nearby, unaffected structures may be much higher or much lower than the building under investigation. As a consequence, it is not possible

[1] These values are based on the *EPA National Ambient VOC Database Update* (EPA, 1988c) and a paper entitled *Assessment of Population Exposure and Carcinogenic Risk Posed by Volatile Organic Compound in Indoor Air* (Stolwijk, 1990).

[2] *Indoor Air Sampling and Evaluation Guide*, WSC#02-430 (2002).

[3] Communicated through a note added to the Indoor Air Background values and an article in the "LSPA Newsletter."

to determine with confidence the building-specific background concentration of a chemical that would be present in the absence of any vapor intrusion pathway.

Indoor air chemical concentrations measured by large-scale scientific studies in comparable buildings, however, provide a range of OHM concentrations commonly observed, absent a release.

Process for Developing MassDEP's List of Typical Indoor Air Concentrations

The process MassDEP followed for identifying appropriate studies, and incorporating data sets from those studies into an updated list of Typical Indoor Air Concentrations included:

1. Identifying studies that measured chemical concentrations in residential indoor air (study locations were unaffected by a release of OHM to the environment);
2. Developing evaluation criteria to determine the quality and applicability of the studies;
3. Reviewing each study and applying the evaluation criteria to identify the most appropriate studies to be used by MassDEP in determining the range of typical indoor air concentrations;
4. Determining the 50th, 75th and 90th percentile values from the data sets and incorporating the median values into a table of Typical Indoor Air Concentrations.

Each of these steps is described in more detail below.

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Identification of Studies

The Workgroup initially sought available data sets of indoor air collected using stainless steel SUMMA canisters and analyzed by EPA Toxic Organic (TO) and MassDEP's draft Air-Phase Petroleum Hydrocarbons (APH) methodologies. The universe of data sets was eventually expanded to include a number of studies conducted using passive samplers (e.g., 3M Badges) and sorbent tubes. Over 100 indoor air studies were initially identified and/or provided to the Workgroup for consideration.

Development of Evaluation Criteria

The Workgroup developed the following evaluation criteria to identify the most appropriate studies to be used by MassDEP in determining the range of Typical Indoor Air Concentrations:

"Screen In" Criteria for Indoor Air Studies

1) Primary studies
2) Residential studies
3) Geography and climate similar to Massachusetts
4) Construction of homes similar to Massachusetts
5) Samples collected with canisters, 3M badges, and/or sorbent tubes using current state-of-the-art methodologies
6) Samples collected from basement and living spaces
7) Large volume of data
8) Analytical sensitivity (i.e., low Method Detection Limits)
9) Ambient air data collected for comparison

"Screen Out" Criteria for Indoor Air Studies

1) Occupational studies (e.g., drycleaners, etc.)
2) Related to a release of OHM to the environment (including residences with nearby commercial VOC sources)
3) Dated studies (data collection pre-1990)
4) European studies and those exhibiting strong geographic bias (e.g., very rural Vermont study)
5) Unknown sampling/analytical methodology
6) Presence of atypical indoor sources (unusual use/overuse of product)
7) Non-VOC data
8) Total VOC only data
9) Study unobtainable
10) Elevated Method Detection Limits

Application of Evaluation Criteria

By applying the evaluation criteria to the indoor air studies identified by the Workgroup, eight studies were selected by MassDEP as the best data sets to be used in determining the range of typical indoor air concentrations. See **Attachment A** for the list of selected studies.

Together, these eight studies provide a large number of samples (>1,500) collected in residences with generally low method detection limits, and appropriate quality assurance and quality control (QA/QC). These studies have greater than 25% detection rates for many of the analytes, and reported percentiles values for chemicals.

Determining the 50th, 75th and 90th Percentile Values

Table 1, "Typical Indoor Air Concentrations," provides the 50th, 75th and 90th percentile values derived from the selected studies for forty-two chemicals.

Percentiles from the cumulative frequency distributions data may be obtained from any systematic study that compiles chemical-specific groups of concentration values. A percentile value *p* represents the number in a group of numbers such that *p* percent of the numbers in that group are at that number or below. For example, a 90th percentile concentration for a chemical represents a value for which ninety percent of buildings sampled have indoor air with concentrations of this chemical at or below the reported value. Such percentile data allow for the comparison of indoor air sampling results from a specific building to the collective range of indoor air concentrations monitored in a number of comparison buildings.

For purposes of determining the 50th, 75th and 90th percentile values for chemicals that were detected in the selected studies, MassDEP used only measured (not extrapolated) values. The use of measured values best ensured the accuracy of the data, since the manner in which non-detects (NDs) were reported[4], and the detection limits[5], varied from study to study. MassDEP

[4] For example, some studies substituted the detection limit, or half the detection limit, for reported NDs. Other studies used statistical approaches to estimate a distribution of results below the detection limit or simply reported the value as "< DL."

[5] Since studies with higher detection limits reported a lower rate of detection, the availability of a given percentile value depended on both the prevalence of a chemical in indoor air and the study's detection limit. For example, if a chemical was detected in only 15% of the samples analyzed in a given study, then

believes that relying upon the accuracy of reported percentile values that are estimated concentrations below a study's limit of detection, or using a simplistic approach to estimate the missing percentile value (such as using half the detection limit), may actually decrease the accuracy of the resulting UPVs and is not necessary where there are sufficient ***measured*** values in other studies. Accordingly, MassDEP used the following methodology to determine the percentile values for chemicals with measured values:

- For each chemical, the 50th, 75th and 90th percentile values from each study were identified, to the extent the study reported these percentile values of its data;
- Each value was compared to the study's Detection Limit, and values falling below the reported Detection Limit were eliminated from consideration;
- For each chemical and for each targeted percentile value, the median of the available study percentile values was determined. The median value, rather than the mean, was used because outliers can greatly affect the mean, whereas the median is less affected by outliers. Only actual measured results were considered in determining the median.

MassDEP considers 75th and 90th percentile values or "Upper Percentile Values" (UPVs) in Table 1 as appropriate values for comparison to measured indoor air concentrations as one line of evidence in evaluating whether a building is affected by a vapor intrusion pathway from a disposal site. Because the ranges of Typical Indoor Air Concentrations and potentially site-related concentrations overlap, it is not possible to identify a percentile below which measured concentrations are unlikely in all cases to be site-related *and* above which measured concentrations are likely in all cases to be site-related. Choosing a lower percentile value as a reference value increases the likelihood of erroneously concluding that a detected concentration is site-related, while choosing a higher percentile increases the likelihood of erroneously concluding that a detected concentration is not site-related. Consideration of the UPVs as comparison values increases the confidence that measured indoor air concentrations above the UPVs may more likely than not be associated with a vapor intrusion pathway from a disposal site.

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a 90th percentile value could be identified (requiring at least a 10% detection rate), but not a 75th percentile value (which requires at least a 25% detection rate).

Table 1 Typical Indoor Air Concentrations

Chemical	CAS no.	Percentile Values from Studies (µg/m^3)		
			Upper Percentile Values	
		50th%	75th%	90th%
ACETONE	67-64-1	26	52	91
BENZENE	71-43-2	2.3	3.6	11
BROMODICHLOROMETHANE	75-27-4	ND	ND	ND
BROMOFORM	75-25-2	ND	ND	ND
BROMOMETHANE	74-83-9	ND	ND	0.6
CARBON TETRACHLORIDE	56-23-5	0.54	0.62	0.86
CHLOROBENZENE	108-90-7	ND	ND	ND
CHLOROFORM	67-66-3	1.9	2.6	3.0
DIBROMOCHLOROMETHANE	124-48-1	ND	ND	ND
DICHLOROBENZENE, 1,2- (o-DCB)	95-50-1	ND	ND	0.72
DICHLOROBENZENE, 1,3- (m-DCB)	541-73-1	ND	ND	0.6
DICHLOROBENZENE, 1,4- (p-DCB)	106-46-7	0.5	0.9	1.5
DICHLOROETHANE, 1,1-	75-34-3	ND	ND	ND
DICHLOROETHANE, 1,2-	107-06-2	ND	ND	ND
DICHLOROETHYLENE, 1,1-	75-35-4	ND	ND	ND
DICHLOROETHYLENE, CIS-1,2-	156-59-2	ND	ND	ND
DICHLOROETHYLENE, T-1,2-	156-60-5	ND	ND	ND
DICHLOROMETHANE (MeCl)	75-09-2	1.4	3.7	11
DICHLOROPROPANE, 1,2-	78-87-5	ND	ND	ND
DICHLOROPROPENE, cis, 1,3-	10061-01-5	ND	ND	ND
DICHLOROPROPENE, trans, 1,3-	10061-02-6	ND	ND	ND
DIOXANE, 1,4-	123-91-1	ND	ND	ND
ETHYLBENZENE	100-41-4	1.5	2.4	7.4
ETHYLENE DIBROMIDE	106-93-4	ND	ND	ND
HEXACHLOROBUTADIENE	87-68-3	ND	ND	4.6
METHYL ETHYL KETONE	78-93-3	3.4	5.3	12
METHYL ISOBUTYL KETONE	108-10-1	0.33	0.86	2.2
METHYL TERT BUTYL ETHER	1634-04-4	3.5	6.9	39
NAPHTHALENE	91-20-3	ND	ND	2.7
C5 to C8 Aliphatics	NOS	58	130	330
C9 to C12 Aliphatics	NOS	68	110	220
C9 to C10 Aromatics	NOS	ND	ND	44
STYRENE	100-42-5	0.63	1.1	1.4
TETRACHLOROETHANE, 1,1,2,2-	79-34-5	ND	ND	ND
TETRACHLOROETHYLENE	127-18-4	1.4	2.4	4.1
TOLUENE	108-88-3	11	21	54
TRICHLOROBENZENE, 1,2,4-	120-82-1	ND	ND	3.4
TRICHLOROETHANE, 1,1,1-	71-55-6	0.5	1.1	3.0
TRICHLOROETHANE, 1,1,2-	79-00-5	ND	ND	ND
TRICHLOROETHYLENE	79-01-6	0.29	0.68	0.8
VINYL CHLORIDE	75-01-4	ND	ND	ND
XYLENES (Mixed Isomers)	1330-20-7	5.9	9.4	28

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Attachment A List of Selected Studies Used to Develop List of Typical Indoor Air Concentrations

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Weisel, Clifford P, Junfeng Zhang, et al. 2005. Relationships of Indoor, Outdoor, and Personal Air (RIOPA). Part I, Collection Methods and Descriptive Analyses. Health Effects Institute. Research Report 130 (Pt. 1): 1-127.

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